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DEPARTMENT OF AGRICULTURE,
NEW SOUTH WALES.

SCIENCE BULLETIN, No. 11. October, 1914.

UNIV. OF CALIFORNIA

WHEAT IMPROVEMENT IN AUSTRALIA.

By

F. B. GUTHRIE, F.I.C.

Workers in the respective branches of Economic Science covered by this series of Science Bulletins will receive such of them as may be of use in their special branches of study upon application to the Under Secretary, Department of Agriculture, Sydney.

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1. Read before the British Association for the Advancement of Science, Sydney Meeting, August, 1914.
2. Read before the Third International Congress for Tropical Agriculture, London, June, 1914.

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PART I.

General discussion of the problems involved, and some results obtained.

In *Science Bulletin* No. 7, published by the Department of Agriculture of New South Wales, and dealing with "Wheat and Flour Investigations" carried out by the Department, a short introductory account was given of the encouragement afforded to the study of wheat-improvement in Australia by the labours of the Interstate Rust-in-wheat Conferences.

In the present Bulletin it is proposed to review shortly the work done in the different States of the Commonwealth, and particularly during the past four or five years, towards the improvement of wheat, both by individual workers and as a result of departmental action.

As was pointed out in the publication referred to, the first concerted official action in the direction of studying and improving the locally-grown wheats was made in 1890, when an interstate conference was called to deal specifically with the question of combating rust, which was at that time very prevalent in all the States. In South Australia alone it was estimated that the damage due to this cause in 1899 amounted to £1,500,000.

The result of these conferences, at which the Agricultural Departments of all the States were represented, was to give an impetus to the systematic study of the wheat-plant, with the special object of improving the grain itself, and the methods of soil treatment and crop production. Wheat-breeding stations were established by the various State Departments, and systematic experiments were carried out at the farms and stations under Government control, in order to determine the best varieties for different districts, the most suitable manures, the best treatment of the soil, methods of combating disease, &c.

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Farmers were supplied with seed-wheat, pure and true to name, advised as to their special requirements, and encouraged to experiment on their own account.

The present paper will be confined to a review of the work done in the improvement of the grain itself, either by selection from types already established, or by the creation of new varieties by cross-fertilisation.

Before this concerted official action there had been a great deal of good work done by individual enthusiasts working without much encouragement. In addition to Mr. Wm. Farrer, of New South Wales, who has been called by one of his fellow wheat-breeders "The Father of Wheat-breeding in Australia," and who had been at work since 1882, the names of Mr. James Ward and Mr. Richard Marshall, of South Australia, Dr. Bancroft, of Queensland, Messrs. McAlpine and Pye, of Victoria, Mr. Maddox, of Tasmania, and Mr. Berthoud, of New South Wales and West Australia, were prominent among those who, either by the creation of new varieties or the study of the rust fungi, had done excellent service in the matter of wheat improvement before 1890.

The work of Wm. Farrer has been dealt with in other publications, and it is not proposed to refer more specifically to it in this place. At the same time, no discussion on the question of wheat improvement in Australia would be complete without a reference to the position now occupied by the varieties of which he was the creator, or to his own position as the most successful and inspiring of investigators in this particular line. It is not too much to say that every one who has taken up the subject of wheat-breeding in Australia has owed his inspiration either directly or indirectly to Farrer. The wheats now grown in New South Wales, and only to a somewhat smaller extent in the other States, are Farrer wheats, which have supplanted the older varieties in the popular estimation. How far this is the case in New South Wales will be seen from the list of varieties recommended by the Department, which is given on page 17. Wheats like Federation, Bobs, and Comeback are universal favourites in all the States. So much is this the case, that his immediate successor, Mr. G. L. Sutton, in a paper contributed to the Australasian Association for the Advancement of Science, points out that the Australian harvest must no longer be described as a golden harvest, but as a brown one, on account of the prevalence of Federation with its brown heads.

Its popularity in Victoria is attested by Professor T. Cherry, past Director of Agriculture, Victoria, in the report of the Department of Agriculture, 1907-1910. He says, "The increased yield due to the amount of Federation wheat grown has been estimated at 1,000,000 bushels in the case of last season's harvest (1909-1910). No other variety has, up to the present, been found to give such uniformly good results in all parts of Australia."

In another report the same authority states that in 1909 probably one quarter of all the wheat grown in Victoria was Federation, and estimates that the value of the increased harvest due to this wheat was £250,000.

It must be remembered that Federation was only introduced to Victorian farmers in 1904, and that it does not possess an attractive appearance in the field.

For the best rust-resistant wheats, for the best drought resisters, for the most prolific and the best milling wheats, the farmer turns to the list of Farrer wheats to find one suitable to his district. For a good description of his work the above-mentioned paper of Mr. Sutton's * may be consulted, also another read at the same meeting by Mr. W. S. Campbell,† late Director of Agriculture in New South Wales, to which latter gentleman the State owes the engagement of Mr. Farrer as Wheat Expert to the Department, a recognition of his services that proved of incalculable benefit both to the Department and to Mr. Farrer himself.

Also, a paper read at the meeting of the British Association in Sydney, 1914, by Mr. J. T. Pridham, contains a good account of the results of Farrer's work.‡

It is gratifying to know that Farrer's work has received substantial recognition in his own State at least. A fund has been subscribed by the public, supplemented by a Government grant, to endow a Farrer Research Scholarship. The first Farrer Research scholar (Mr. W. L. Waterhouse) has completed an investigation, which has been published (*Science Bulletin* No. 10) by the Department of Agriculture of New South Wales, under the title "The Effect of Superphosphate on the Wheat Yield in New South Wales." With the money now in hand it is hoped to enable the next Farrer Research scholar to study wheat-breeding in one of the European or American Universities.

Other scholarships have been presented by the two leading Sydney newspapers; one such is awarded annually at the Hawkesbury Agricultural College. The exhibit of wheats competing at the Royal Agricultural Society's Show are housed in a "Farrer Court," &c.

Characteristics specially sought for in Improved Varieties.

The specific points to which attention has been more particularly directed in the production of improved types of wheat have been the following:—

1. Immunity against rust and other diseases.
2. Prolificness.
3. Drought resistance.
4. Improvement of milling qualities.
5. Creation of wheats for hay.
6. Creation of wheats for different districts.

* G. L. Sutton.—"The Realisation of the Aims of William J. Farrer, Wheat-breeder," Australasian Association for Advancement of Science, vol. XIII, p. 536.

†W. S. Campbell.—"An Historical Sketch of Wm. Farrer's Work, in connection with the Improvements in Wheat for Australian Conditions," *ibid.*, vol. XIII, p. 52.

‡J. T. Pridham.—"William Farrer's Work, Methods, and Success," British Association for the Advancement of Science, Sydney meeting, August, 1914.

As the conditions of wheat-growing in Australia differ in many material points from those prevailing in other countries, most of the above terms possess a significance different to that which attaches to them elsewhere. It is therefore desirable to provide some explanation of local conditions and of the problems which confront local wheat-growers.

It must be borne in mind that wheats which are pre-eminent locally on account of special characteristics are often failures, even as regards such characteristics, when grown abroad, and *vice versa.*

Mr. H. Pye, Principal of Dookie Agricultural College, Victoria, reports* that some of the more noted English wheats, including Essex Conqueror, Square Heads Master, Doggett's Pride and Garforth, all yielded below 20 bushels to the acre when grown on the experiment plots at Dookie, as against 31 to 32 bushels given by the most prolific Australian varieties.

Some samples of several of our best rust-resisting wheats were forwarded to Mr. A. E. Humphries (Past-President of the National Association of English and Irish Millers) for trial under English conditions, in the hope that they might prove useful in the production of improved varieties. His report† was to the effect that everyone of them had proved absolute failures when grown in England, and were eaten up by rust.

The well-known strong-flour Fife wheats, which were first imported several years ago, and which, it was hoped, would provide us with a better milling wheat, were found to be quite unsuitable on account of their low yields when grown under local conditions. They did, however, retain their strong-flour characteristics, and have proved of great value as parents, many of Mr. Farrer's most successful crosses containing Fife blood. We in Australia have had, therefore, to work out our own salvation in the matter of providing improved grain, and the question is complicated by the fact that provision has to be made for all sorts of different conditions as to soil and climate, the latter varying from the moist coastal districts to the semi-arid country, and from the cool tablelands to the hot plains.

Rust Resistance.

This was the subject which engaged more particularly the attention of the earlier conferences, and was immediately made the subject of special investigations.

The names of Mr. D. McAlpine and Dr. N. A. Cobb, vegetable pathologist of the Agricultural Departments in Victoria and New South Wales respectively, are prominent in connection with this work. Mr. Farrer also devoted a great deal of attention to the subject, and a large number of his crosses were made with the object of producing rust-resisting or rust-escaping varieties.

* Report of Principal, Dookie Agricultural College, for year ending July 31st, 1910. Published by the Council of Agricultural Education, Victoria.

† A. E. Humphries "on the behaviour of certain Australian varieties of wheat when grown in Surrey (England)." Australasian Association for Advancement of Science, vol. XIII, page 542 (reprinted in abstract in *Agricultural Gazette for New South Wales,* vol. XXII, p. 382).

Reference has been made to the fact that the qualities which confer rust-resistance locally are by no means identical with those which are required in other countries. The disease itself exhibits certain characteristics which differentiate it from European or American rusts. Mr. D. McAlpine, who is the Australian authority on the subject, finds that of the three kinds of rust which attack the wheat-plant, namely *Puccinia graminis,* or Black rust (Summer), *Puccinia dispersa,* or Brown rust (Spring), and *Puccinia glumarum,* or Yellow rust (Spring), the only one that is destructive in Australia is *P. graminis*; of the others, *P. glumarum* does not occur in Australia, and *P. dispersa* does little or no damage.

Mr. McAlpine has further shown that the life history of the Black rust in Australia differs from its life history in Europe and America. A notable example is the fact established by him that the barberry, which is said to act as intermediary host for this fungus in Europe, does not function in this capacity in Australia. McAlpine concludes that the principal harbourers of the disease in the intermediate (aecidio-spore) stage locally are the grasses, cocksfoot (*Dactylis glomerata*), foxtail (*Alopecurus pratensis*), and tall or meadow oat-grass (*Avena elatior*).

Mr. McAlpine's principal work in this connection has been carried on for a number of years in experimental plots at Port Fairy on the Victorian coast, a district particularly liable to rust. Here a great number of wheats have been under observation for many years, including selected strains of varieties known to be fairly rust-resistant and many of Mr. Farrer's crosses.

As early as 1898 Mr. McAlpine was able to report * that "it may be safely asserted that sufficient has now been done by way of experiment to show that our wheats may be greatly improved, and that rust-resisting strains may be reared." . . . . "Here, in a district which is admitted to be one of the most liable to rust, wheats have been under trial as long as eight years, and have stood the test."

Mr. J. T. Pridham, Plant-breeder to the New South Wales Department of Agriculture, and a successor to the late Mr. W. Farrer, also reports that as the result of the work in New South Wales considerable success has attended the creation of rust-escaping varieties, and that for the last few years little damage has been done in the coastal districts of New South Wales, where the disease had been so bad as practically to stop the cultivation of wheat.

Certain quick-maturing varieties (amongst the best of which is a Farrer cross-bred known as Warren) actually yield better under rusty conditions than others which are more resistant to rust but mature later.

At the same time, early maturity is not in itself a sufficient protection against rust, as some of the earliest wheats are amongst the most rust-liable. The Indian wheats are examples of this.

A great deal of work in the direction of selecting and testing rust-resistant varieties has been done at the Hawkesbury Agricultural College, near Sydney. Though this is not a wheat-growing district, it is very subject

* Guides to Growers, No. 37.—Wheat experiments, season 1897-98, issued by the Department of Agriculture, Victoria.

to rust, and was on this account chosen by Mr. Farrer as the most suitable place for testing his rust-resistant crosses. Mr. H. W. Potts, the Principal, reports that, as the result of many years' work, two varieties are found to stand out above all the others. These are two Farrer crosses, Warren and Thew, and these are the varieties now demanded by the costal farmers of New South Wales for hay. (It should be mentioned that practically no grain is produced in the coastal districts.) Other Farrer wheats, such as Florence, Firbank, and Bunyip, are also successful on account of their maturing early. Bobs was grown successfully for several years, but it ultimately lost its rust-resisting properties. All the wheats mentioned above are Farrer wheats.

An instance of successful selection from unpromising material is afforded by the wheat known as Ward's Prolific (see also page 23). This wheat, which was long a popular favourite in all the States, originated with Mr. James Ward, a South Australian farmer, as long ago as 1881. Mr. Ward received a small parcel of seed of a variety known as Du Toits, grown in South Africa, from Dr. Schomburgh, Director of the Botanic Gardens, Adelaide, which he planted. The crop was very badly affected by rust, with the exception of a single plant, which was free. On planting the seed from this, 1 lb. of grain was obtained the first year, 50 lb. the second year, 28 bushels the third year, and 932 bushels in the fourth year. The plants never exhibited any signs of rust, and the result was the production of one of the best rust-resistant varieties we possess, though it has given place in recent years to other wheats which, while equally rust-resistant, are preferred for other reasons.

Dr. N. A. Cobb, Vegetable Pathologist to the New South Wales Department for several years, carried out a great amount of work on rust in wheat, and published a number of reports and articles embodying the results of his investigations. At the time at which he began this work the nomenclature of the varieties in cultivation was in a deplorable state of chaos. The work of reducing the confused nomenclature then existing to some sort of system involved the careful examination of hundreds of varieties in the field and under the microscope, and included accurate measurements of all parts of the living plant and of the grain.

During recent years the number of the varieties in cultivation have been reduced to comparatively very few, and new varieties have superseded those dealt with by Dr. Cobb, but his work in this direction was of great value to the wheat-breeder and farmer by systematizing the nomenclature and enabling wheat to be grown true to name.

Prolificness.

This is the property which the farmer looks for in the first instance, and in the days before 1890 it was the only one to which he attached much importance. Unfortunately many of the wheats then grown on account of

their good acre-yield possessed or developed objectionable qualities, such as being liable to rust or affected by dry spells or of poor milling quality.

In discussing the question of prolificness it is important to remember that this term also possesses a significance very different to that which it has in Europe.

Harvests of 50 to 60 bushels to the acre are unknown on the Australian continent. The highest individual yield of which I can find any record as being obtained from a reasonable area is one of 43 bushels given by a new Victorian variety, Commonwealth; *see* page 21.

The average yields per acre for the past five harvests in the individual States are as follow:—

	1908-9.	1909-10.	1910-11.	1911-12.	1912-13.
New South Wales	11·11	14·34	13·11	10·54	14·6
Victoria	13·12	13·72	14·52	9·65	12·6
South Australia	11·45	13·26	11·57	9·29	10·3
West Australia	8·63	12·48	10·14	7·12	11·6
Queensland	14·87	13·41	9·58	6·64	15·8
Tasmania	24·08	21·41	21·45	17·73	25·0
Commonwealth ...	11·89	13·73	12·90	9·64	12·5

It is to be noted that the Australian harvest is gathered between November and January, so that the figures for 1908-1909 give the harvest of November or December, 1908, and January, 1909, and represent the grain available for 1909.

With the exception of Tasmania, where the area under wheat is very small, and which has little effect on the Commonwealth figures, the average yield for any State rarely exceeds 14 bushels, and is a low one in comparison with most other wheat-producing countries.

The character of prolificness being one that appeals strongly to the farmer, it is natural that a considerable number of "improved" wheats are constantly being produced by the farmers themselves. These are in nearly all cases obtained by selecting grain from the standing crop and sowing it separately. Many of these wheats enjoy local favour, but as a rule the prolific character is not retained for more than two or three seasons, or after the wheat leaves the hands of the original selector, and these wheats will not be noticed here.

As a large and increasing proportion of our wheat area is in districts with a comparatively low rainfall, the question of prolificness is closely bound up with that of drought resistance.

Mr. H. Pye,* the Principal of Dookie Agricultural College, Victoria,

* Report of the Principal, Dookie Agricultural College, Victoria, for the year ending 31st July, 1909.

summarises the characteristics which make for prolificness in a wheat under Australian conditions as follows:—

1. Well-developed root system.
2. Strong tillering or stooling property.
3. Long ears.
4. Dense or close ears or an increased number of spikelets per ear.
5. Increased number of fertile florets per row of spikelets.
6. Large and heavy grain.

Wheats with the above characteristics are the most likely to withstand droughty conditions, and to hold their grain well, at the same time allowing the grain to be threshed readily.

Drought Resistance.

The problem of creating, either by selection or by cross-breeding, varieties which will yield well under comparatively dry conditions is one of the most important which presents itself to the breeder of improved wheats for Australian conditions. It is also the one in the solution of which some of the most striking successes have been achieved by our wheat-breeders. The future extension of the wheat area depends upon the cultivation of wheat in districts with a considerably lower rainfall than is at present considered the minimum. With improved methods of cultivation and fallowing, and the selection of such wheats as are best able to withstand dry conditions, wheat is now being profitably grown in districts which, a few years ago, were regarded as unsuitable.

As the development of these wheats proceeds, and with the use of motor traction and multiple ploughs and the application of proper soil management, our best authorities are agreed that wheat-growing on the large scale will be successful in drier areas than have yet been farmed. Light sowings and light manuring are also factors in successful wheat-culture in such areas.

The characteristics to be looked for in wheats for dry districts are summarized as follows by Mr. McAlpine,* who has made a special and extended study of the wheats suitable to the so-called Mallee district of Victoria. "They must be early-maturing to escape the hot winds, drought-resisting, holding the grain well (since the grain must be dead ripe for harvesting with the stripper). They must, in addition, be good milling wheats, prolific, and fairly rust-resistant."

It may be said that the production of wheats with the above characteristics and modified to suit the exigencies of the varying soils and climate met with in different parts of Australia, constitutes the problem of the local wheat-breeder.

* Report on wheat experiments at Port Fairy and in the Mallee, season 1899-1900, by D. McAlpine, Vegetable Pathologist; published by Department of Agriculture, Victoria (March, 1900).

A good example of what may be achieved in the cultivation of wheat in dry areas under good methods of soil treatment, and with suitable varieties of grain, is afforded in the same investigator's report on his experiments in the Mallee for 1900.*

The total rainfall for the year was 13·24 inches (about the average for the district), of which only 7·38 inches fell during the growing period (April to October, inclusive). The average yield for the district was about 5 bushels.

The experiment plots were one-acre blocks, and were stripped in the usual way. The average from these was 18 bushels per acre. The wheats that yielded best were Queen's Jubilee and Outpost (two Farrer wheats) and Improved Allora Spring. These all gave over 20 bushels.

The Mallee district of Victoria is a tract of about 11,000,000 acres in the northern part of the State, deriving its name from the scrub that largely covers it.

The rainfall is low, and frequently falls below 10 inches during the period of growth of the crop, as in the above instance. Other dry-country varieties will be dealt with when the work done in the different States is discussed.

Milling Quality.

Even with regard to the requirements of a good milling wheat there is a difference between Australian conditions and those obtaining elsewhere. In the first place, the Australian miller produces practically only one grade of flour—a straight grade. Grades such as bakers', patents, households, &c., are hardly known, and only a small proportion of flour is exported. It is true that in the last few years an export trade has established itself, but the trade is not yet sufficiently extensive to modify existing methods to any extent. Moreover, the Australian miller deals only with locally-grown wheats which are fairly uniform in character, so that blending, as understood in other countries, is unknown.

The only modifications consist in the production of more or less offal, according to the state of the market.

Consequently the characteristics of a wheat to be acceptable to the Australian miller are that it shall not differ greatly from the prevalent type, and that it shall yield a good quantity of straight-grade flour of good colour and baking quality.

In recent years the question of milling quality in wheat is receiving more general attention in Australia than formerly. Until the past few years the production of new varieties of good milling quality was practically confined to New South Wales, and Mr. Farrer's work distinguished itself from that of other wheat-breeders, in the fact that he allowed no new variety to go into cultivation unless it was a good miller's wheat. The work done by the New South Wales Department in this direction is described fairly

* Report for the year 1900, by D. McAlpine, Vegetable Pathologist; published by Department of Agriculture, Victoria.

fully in the paper already referred to, and which was originally read before the Congress for Tropical Agriculture at Brussels, 1911, and which is reprinted as *Science Bulletin* No. 7, issued by the New South Wales Department of Agriculture.

Mr. G. W. Norris has been exclusively engaged here on this work for some years past, and his results have been of the greatest value, not only to the wheat-breeder, but to all interested in the wheat industry.

During the past few years small wheat-testing mills have been established by the Agricultural Departments in Victoria, Queensland, and West Australia, and their operations will be dealt with in the succeeding section.

It is to Mr. Farrer that we owe the most striking successes in the production of wheats of high milling excellence. As has been already pointed out, the improvement of our local wheats in regard to their milling quality was the aim he kept steadily in view. Many of his most popular wheats, such as Federation, were crosses between local weak-flour favourites and strong-flour wheats of the Fife family. The Farrer wheats are therefore all distinguished in being good milling wheats, and, in addition, he has created new types of specially high flour-strength, principally by admixture of Fife and Indian blood. These wheats it has been proposed to name "New South Wales Strong White," or preferably, from my point of view, "Australian Strong White." This type, represented by wheats like Bobs and Comeback, yield flours equal in strength to any on the market. The result has been that as the Farrer wheats grow in popularity and come more into general cultivation, a marked improvement in the gluten content, flour strength and general milling quality of Australian wheats is becoming apparent.

Mr. Farrer's immediate successor as wheat-breeder, Mr. G. L. Sutton (now Agricultural Commissioner in Western Australia), took up this work very keenly, and has continued breeding and selecting for milling excellence and flour strength, so that the present strong-flour wheats are better milling wheats to-day than when Mr. Farrer left them.

Mr. Sutton was also chiefly instrumental in popularising the Farrer wheats, raising pure pedigree seed in large quantities for distribution to farmers. Another result of Mr. Sutton's work as wheat-breeder was that by this means he was able to introduce the best varieties into general cultivation, thus enabling the Department to reduce the number of varieties recommended to about twenty (*see* list on page 17).

All these varieties, while equally prolific, or even more prolific, than the discarded ones, are greatly superior as milling wheats.

Mr. Sutton's successor, Mr. J. T. Pridham, who was also a student of wheat-breeding under Mr. Farrer, has continued the work, and has been particularly successful, as has been mentioned above, in improving some of the Farrer wheats to suit dry conditions.

A few of the most popular of these strong-flour wheats may be briefly described in this place.

Bobs was the first of Mr. Farrer's wheats to be cultivated on the commercial scale. This is a true hybrid, being a cross between a strain of Blount's Lambrigg and Nepaul or Bald Skinless Barley. It is a remarkably good milling wheat, and Mr. A. E. Humphries, Past-President of the National Association of British and Irish Millers, reported that Bobs flour was the best Australian flour he had ever handled, and compared favourably with Manitoba flour. Bobs is one of the "Strong-white" class.

Comeback, another of the "Strong-white" class, is a Fife-Indian cross. It is a superior milling wheat to Bobs, and such a milling authority as Mr. M. Kahlbaum, Manager of the Adelaide Milling Company, Limited, has stated that its flour is better than the best imported Manitoba.

It is a rather peculiar fact that Comeback does not appear to thrive in districts of very cold winters, thus disposing of the statement that used to be made, and is still frequently met with, that the excessive cold of the Canadian winters is the dominant factor in the production of the strong-flour Canadian wheats.

As a matter of fact, Comeback is particularly affected by frosts, and for this reason must be sown fairly late.

Both these varieties, though created specially for their strong-flour characteristics, are fairly prolific. Bobs has given 40 bushels to the acre, and both are good hay wheats.

Cedar.—This is the best of all the milling wheats created by Mr. Farrer, and produces stronger flour than either Bobs or Comeback, and is a remarkably heavy wheat.

This season samples have gone up to 67½ lb. per bushel. It is also remarkably rich in gluten, averaging about 15½ per cent. dry gluten. Like Comeback, it is a Fife-Indian cross, but, unlike Comeback, it is a red wheat, and if the name "Australian Strong-white" is to be adopted for Bobs and Comeback and similar wheats, Cedar would be classed as "Australian Strong-red." It has consistently taken the champion prize for the last four or five years for the best bag of wheat exhibited at the Royal Agricultural Society's Show in Sydney, and was the winner at the last Melbourne Show. It has consistently beaten Manitoba grain in the "Hard Red" class.

Federation.—Though not a strong-flour wheat, this wheat must be mentioned here because it was the first successful attempt to improve the flour strength of the wheats grown in Australia at the time. These wheats were very similar to the Californian wheats, and were characterised as plump, starchy grain, yielding flour of low strength, and white in colour. This class of grain is typified by Purple Straw, and Federation is a cross between Purple Straw and a Fife-Indian cross called Yandilla by Mr. Farrer.

It was created with the object of producing a variety with short, stiff straw, suitable for the Australian method of harvesting with the stripper, and at the same time of improving the flour strength of the grain. It is, as has been already mentioned, the most popular grain wheat in Australia. It is not a good hay wheat.

The question of improving the bread-making value of our wheats is of the greatest importance in view of the expansion taking place in our wheat-producing area and the increasing demand for Australian wheat. As the immediate object of growing wheat is to convert it into flour to make bread, it is important to keep its bread-making quality in mind if we are to hold our own with bread-wheats in the world's markets.

The following table gives the Commonwealth export of wheat and flour for the past few years:—

COMMONWEALTH EXPORTS OF WHEAT AND FLOUR.

	Export of Wheat.	Export of Flour.
	Bushels.	(Equivalent to bushels, wheat).
1907	28,784,130	8,171,900
1908	15,027,338	5,840,150
1909	31,549,498	6,498,450
1910	47,761,895	6,997,300
1911	55,147,840	8,794,550
1912	32,604,000	8,405,000
1913	42,923,000	11,096,000

Wheat is exported principally to Great Britain. The flour goes to South Africa, Great Britain, Java, Portuguese East Africa, Philippine Islands, and the Straits Settlements, in the order named.

In 1901 the Commonwealth *imported,* of wheat 22,992 bushels, and of flour the equivalent of 302,550 bushels, whereas in 1911 these figures were—wheat 113 bushels only, and flour equivalent to 12,150 bushels.

Put in another way, the total net exports of breadstuffs (wheat and flour equivalent to wheat), which was 24,775,216 bushels in 1901, was 63,930,127 bushels in 1911.

Not only is the volume of the export trade in breadstuffs thus increasing, but the price of Australian wheat on the English market, though subject to considerable fluctuation, is a steadily increasing quantity. The following table gives the prices for wheat in London for the past ten years:—

Year.	Price in London (quarter of 8 bushels).
1904	31 4
1905	32 4
1906	31 2
1907	33 8
1908	37 7
1909	41 5
1910	37 2
1911	34 10
1912	38 5
1913	39 6

PART II.

Work done in the Improvement of Wheats in the different States.

NEW SOUTH WALES.

Departmental Action.

Wheat experiments are conducted at Cowra (the headquarters for wheat-breeding), Hawkesbury Agricultural College (representing the coastal districts), Wagga (representing the Riverina, the principal wheat-producing district of the State), Bathurst (Central Tablelands), Glen Innes (Northern Tablelands), Nyngan and Coonamble (dry western country), and Yanco (under irrigation).

It will thus be seen that the varying conditions as to climate, rainfall, &c., are represented at the different stations. At these stations the work includes:—

(*a*) Pedigree plots of the main varieties grown on the farm;

(*b*) Cross-bred varieties in course of fixation for local conditions;

(*c*) "Seed variety trials," including standard varieties, newly introduced wheats, and samples sent for identification;

(*d*) "Stud bulk plots" to provide seed for planting the

(*e*) "Farm areas," which in their turn supply seed-wheat to the farmers.

In addition to the above colleges and farms, there are seven or eight more, at all of which (except those specially established for viticulture, dairying, &c.) wheat-growing is carried on.

At Cowra, where the wheat-breeding is carried on under the direction of Mr. J. T. Pridham (Mr. Farrer's successor), the principal work now being done is the cross-breeding and selection of wheats for special purposes and different districts. Mr. Pridham was an assistant to Mr. Farrer for three years, and has been in his present position of plant-breeder since 1911.

During the past season he has rejected a large number of crosses of inferior value, and has paid more attention to selection from existing crosses than to the creation of new ones.

Attempts to secure varieties which are immune from bunt have been discontinued, as it was found that though highly resistant varieties had been produced, complete immunity was never secured, and it has been decided to rely on pickling seed-wheat, which has been found to be an absolutely reliable preventive. Mr. Pridham is of the opinion that with systematic

selection plots and the use of clean machinery the farmer will be able to dispense with even this precaution. The elimination of the above work has made it possible to extend the area devoted to selections from cross-breds. Fewer new crosses are made, but the number of selections from each cross has been increased.

Selections are also made from field crops, for although their pedigrees are unknown, they often include useful material. These new wheats are presumably the result of natural cross fertilisation, a phenomenon which Mr. Pridham thinks occurs more frequently than is generally supposed.

With regard to drought-resistant wheats, several of the new varieties are extremely promising. It cannot, however, be said of any of them that they are of such general value as Federation.

Among these Mr. Pridham regards Sunset as the most promising. It is not strictly speaking a new wheat, as it is one of Mr. Farrer's original crosses, and had been rejected on account of its low flour strength. It is, however, likely to prove a very valuable variety, as it matures very quickly, and possesses other characteristics which render it admirably suited to dry-country conditions. It is being distributed this season. It is a cross between a sport from Blount's Lambrigg and a cross between White Fife and Summer Club.

It is one of the earliest ripening kinds and amongst the most prolific in dry districts.

Other new wheats which are being distributed this season are:—

Bomen, one of whose parents is Red Potocka and the other a cross-bred wheat containing Fife and Indian blood. It was first made in 1901, and proved bunt-resistant. It ripens a little later than Federation, and is a rather weak-flour, prolific variety, with good straw.

Canberra.—A cross between Federation and Volga barley (a two-row sort contained as an impurity in a sample of wheat received from Russia). Canberra is an early-ripening, prolific wheat, its defects being that it is rather weak in the straw, and has a slight tendency to shell. It yields a high percentage of flour of first-rate colour and good strength.

Nardoo is another promising cross, containing Fife and White Naples amongst its parentage. It is a smut-resistant variety, and a particularly promising hay wheat, though good for grain, also yielding a flour of medium strength.

At the other farms the wheats produced at Cowra are tested for their suitability for different districts, and grown in the variety trial plots. Those that prove valuable are grown on the larger scale in the stud plots and distributed to farmers.

The following list, which gives the varieties recommended by the Department for the present season's sowing, represents the final stage of the Department's action in this direction. The wheats which are underlined are Farrer wheats.

WHEATS recommended for cultivation in the different districts of New South Wales.

A.—DUAL-PURPOSE WHEATS.

Recommended for both Grain and Hay.

Variety.	Period of Sowing.	Districts.
Bobs	Mid-season and late	Central Tableland; Central-western Slopes.
Cleveland	Early and mid-season	Central Tableland; Cooler portions of North-western Slopes, Central-western Slopes, and South-western Slopes.
Comeback	Late	South-western Slopes and Riverina.
	Mid-season and late	Central-western Slopes; Western Plains.
Firbank	Mid-season and late	Central-western Slopes; Western Plains.
Florence	Mid-season and late	Central-western Slopes; South-western Slopes and Riverina; North-western Slopes; Central Tableland; Northern Tableland; Western Plains.
Haynes' Blue-stem	Very early	Northern Tableland.
Marshall's No. 3.	Early	South-western Slopes and Riverina.
	Early and mid-season	Central Tableland; Central-western Slopes; North-western Slopes.
Rymer	Mid-season	Central Tableland.
	Early mid-season	South-western Slopes and Riverina; Central-western Slopes; North-western Slopes.
Thew	Mid-season and late	Northern Tableland; Central-western Slopes.
Warren	Early, mid-season, and late mid-season.	Coastal.
Yandilla King	Early	South-western Slopes and Riverina.
	Early and mid-season	Central Tableland; North-western Slopes; Central-western Slopes.

B.—WHEATS FOR GRAIN ONLY.

Not recommended for Hay.

Variety.	Period of Sowing.	Districts.
Bunyip	Mid-season and late	South-western Slopes and Riverina; Central-western Slopes.
	Late	North-western Slopes; Western Plains.
Federation	Mid-season	Central Tableland; South-western Slopes and Riverina; Central-western Slopes; North-western Slopes.

C.—Wheats for Hay only.

Not recommended for Grain.

Variety.	Period of Sowing.	Districts.
Firbank	Mid-season and late	South-western Slopes and Riverina; North-western Slopes.
Huguenot	Early, mid-season, and late	Coastal.
John Brown	Early, mid-season, and late	Coastal.
Steinwedel	Early and mid-season	Western Plains; Central-western Slopes; and drier portions of South-western Slopes and Riverina.
Thew	Mid-season and late	Coastal; South-western Slopes and Riverina; North-western Slopes.
Zealand	Early	Central Tableland; South-western Slopes and Riverina; Central-western Slopes.

D.—Wheats Suitable for Green Feed and Soiling.

Variety.	Period of Sowing.	Districts.
John Brown	Early and mid-season	Coastal.
Huguenot	Early and mid-season	Coastal.
Thew	Early, mid-season, and late	Coastal; North Tableland; North-western Slopes.
Florence	Early, mid-season, and late	Coastal.

E.—Wheats for further trial.

Variety.	Period of Sowing.	Districts.
Cedar	Early and mid-season	North-western Slopes.
Sunset	Late	Western Plains.
Bomen	Mid-season	Central-western Slopes; South-western Slopes and Riverina; North-western Slopes.
Genoa	Early and mid-season	Northern Tableland.
Canberra	Mid-season and late	Central-western Slopes; South-western slopes and Riverina.
Nardoo	Mid-season	Central Tableland; Northern Tableland North-western Slopes.

F.—WHEATS TO BE GROWN UNDER IRRIGATION.

In experiments carried out by the Department the following wheats have given the best results when grown under irrigation for hay and green fodder:—

1. Zealand.
2. Marshall's No. 3.
3. Florence (late sowing).

It will be noticed that of the twenty-four separate varieties recommended, no less than eighteen are Farrer wheats, and a nineteenth, Yandilla King, has a Farrer wheat, Yandilla, as one of its parents.

Another way in which the New South Wales Department encourages the study of wheat-improvement and incidentally the improvement of other crops, is by means of Farmers' Experiment Plots. These were introduced some years ago by Mr. G. Valder (Under Secretary and Director of Agriculture). As far as wheat is concerned, these include variety trials and manure experiments carried out by the farmers themselves under the supervision of an officer of the Department. The scheme has worked admirably in encouraging farmers to take an interest in improved methods of cultivation and in selecting the most suitable varieties of crops, and particularly in bringing them into close touch with the Department. These plots are now under the direction of Mr. Hugh Ross, Chief Inspector of Agriculture.

No better proof could be afforded of the value of these plots as object-lessons to farmers, and as factors in encouraging improved methods of cultivation, than a comparison of the average bushel yields of these experiment plots devoted to wheat with those of farmers working their land under ordinary conditions.

The following table shows the average annual yield per acre for the State (New South Wales) for the past five years, together with the yields obtained from the farmers' experiment plots:—

	Average bushel-yield per acre.				
	1909–10	1910–11	1911–12	1912–13	1913–14
New South Wales	14·3	13·1	10·5	14·6	12·0
Farmer's Experiment Plots	24	18¾	20¼	24	21·0

It is to be noted that the usual size of these plots is 10 acres, only a few being below this area, and others running up to 25 acres, and that the increased yields are due to improved farming, such as selection of suitable seed, proper manuring, and particularly fallowing, with subsequent cultivation to conserve moisture.

The Agricultural Bureau system which has been introduced recently, and which originated in South Australia (*see* page 26), must also be mentioned as one of the means by which the farmer is encouraged by the Department to improve his working conditions, and one which assists incidentally in wheat improvement. Some of the branches of the Bureau have instituted what are known as "Seed-wheat growing competitions," which also originated in South Australia. These competitions extend over a number

of years, the seed used each year being hand-selected from the plot of the preceding year. The area is 5 acres; the ground must be clean or after long fallow, the seed graded and of a variety selected by the Department. The standing crop is cleaned as far as possible by hand-picking of wild oats, strange heads, &c. The award is made according to a scale of marks given for yield, purity of type, freedom from disease, bushel-weight and general appearance. This scheme offers a strong incentive to the farmer to improve the quality of his seed-wheat, and helps him to do so by systematic methods.

The selection of seed to raise "stud plots" for the coming season by individual farmers as distinguished from the above-mentioned bureau scheme, is also encouraged by the Department.

The milling of wheats on a small mill and the testing of flour has been carried on in New South Wales since 1895. This has also been a factor in the improvement of wheat, in that it has enabled the breeder and grower to avoid the propagation of inferior grain and to improve local wheats in respect to milling excellence. The Department is also represented on the Grain Trade Section of the Sydney Chamber of Commerce, part of the activity of which body is to strike the standard of quality for shipping (the F.A.Q., or fair average quality standard).

For many years the Department's mill has been utilised for the purpose of awarding the prizes in the wheat section of the Royal Agricultural Society's Show, the prizes being finally awarded to those wheats which give the best milling results.

VICTORIA.

Departmental action.

Systematic work in the improvement of wheats by selection combined with cross-breeding is carried out at the Government Experiment Farms and Stations at Dookie, Longerenong, Rutherglen, Wyuna and more recently at the Werribee Research Station. Standard varieties are also grown for seed purposes in "stud plots" for distribution as seed-wheat to farmers. An experimental flour-mill is in operation, on which new varieties can be tested for their milling qualities and the flour tested and baked into loaves. This is under the charge of Mr. A. E. Richardson, Superintendent of Agriculture. The mill is also made use of in judging the wheats competing at the Melbourne Royal Agricultural Show.

The Work at Dookie.

The work at Dookie has been the most prolific of results in the production of improved varieties, and a short description of some of the wheats created by Mr. Pye will serve to show the nature of the work accomplished.

Mr. Hugh Pye, now Principal of Dookie Agricultural College, Victoria, was among the first to take up the systematic study of wheat with a view to its improvement.

Mr. Pye was associated with Mr. Farrer as early as 1888, when the work of this investigator first came under his notice. Both worked in co-operation since that time, exchanging new varieties and ideas. At first Mr. Pye's work was chiefly confined to perfecting Mr. Farrer's wheats and selecting them to suit Victorian conditions. Most of the Federation wheat now grown in Victoria is from the original cross. It developed somewhat differently from the same wheat grown in New South Wales, and is a specially prolific strain.

In his most recent report (*vide* report of Principal, Dookie Agricultural College for 1913-14) Mr. Pye laments the fact that he had been handicapped in the early days by not being able to avail himself of the services of a testing mill, so that he was unable to breed for milling excellence and had to devote himself more particularly to increasing prolificness in conjunction with other qualities. Now that a small testing mill is in operation he has the results of twenty years' work to test.

How well he has succeeded in producing good yielding wheats is shown in the following short notes on some of his more successful creations:—

Improved Steinwedel was the first new wheat to be distributed for general cultivation. It is a cross between Steinwedel and Purple Straw, two weak-flour wheats, which were very popular all over Australia at that time. The cross proved to be a drought-resistant, prolific, early mid-season variety, and had the merit of holding its grain well. The original Steinwedel, though one of the best drought-resistant wheats we have, has the defect of shelling badly. This is a very serious drawback in Australia, where the almost universal use of the stripper requires the wheat to be dead ripe before harvesting.

Improved Steinwedel is still largely grown in Victoria.

Warden was the second variety introduced by Mr. Pye. Its pedigree is (Quartz x Ward's White) x Red Bordeaux. This variety was specially selected for its hay-producing qualities, and is still the most popular hay wheat in Victoria. It took the first prize at the last Melbourne Agricultural Show for wheaten hay.

In addition to its qualities as a hay wheat, it is a prolific, drought-resisting variety, and has done well in the other States. In the drought year of 1902 (when the average yield per acre for the Commonwealth was 2·4 bushels), Warden was the only variety that returned over 10 bushels.

College Purple and *Wallace* are other popular crossbreds, the latter being specially suited to the cooler districts.

Of Mr. Pye's more recent creations, the following are particularly promising:—

Commonwealth is a cross between Federation and (Queen's Jubilee x Australian Talavera). In his annual report for Dookie, July 31st, 1913, Mr. Pye reports that this wheat has given excellent results in South Australia and New South Wales, as well as in Victoria. Yields as high as

43 bushels to the acre have been reported, and in several instances it has beaten Federation by 8 bushels. In a dry district in South Australia, where other varieties yielded only 8 to 9 bushels per acre, this wheat gave 15 bushels.

Currawa, a cross between Little Club and (Cretan (a durum) x Northern Champion), is another variety recently distributed. In the first year of its distribution it won first prize in a crop competition. Yields of 30 bushels to the acre and over are common. This season the highest yield recorded is 42 bushels in the north-east of Victoria.

Major is a Federation x Wallace (*see* above) cross, and is to be distributed next season, a bushel being sent to each of the agricultural societies for distribution to selected farmers who report on its behaviour in the field.

It is a weak-flour variety, and has been twelve years under observation.

Yandilla x *Red Bordeaux* is another very promising variety, which will be distributed in the same way the season after next. It has given very high yields in the farm plots for several seasons. This year it yielded in the farm plots at the rate of 47 bushels to the acre.

Moira, a weak-flour wheat of high promise as a prolific yielder.

Work at other Departmental Stations.

During the past few years a considerable amount of attention has been given departmentally to the subject of cereal improvement, and the systematic breeding of cereals has become one of the most important branches of investigational work.

A comprehensive scheme of wheat-breeding has been in existence for the past three years under the control of Mr. A. E. V. Richardson, Agricultural Superintendent, and already very promising results have been obtained. The work of selection and cross-breeding forms the principal feature of the experiment stations at Werribee (Central Research Farm), Rutherglen Experiment Station, and Longerenong Agricultural College.

The plan adopted in the selection plots is the "centgener" test-plot system introduced by Professor W. M. Hays, formerly of the Minnesota Experiment Station, by means of which uniformity of growing conditions, and as far as possible of soil, are assured, and the yield of the plot compared with that of standard centgener plots of the same variety, as an index of its yielding capacity. The selected and graded produce is then sown in larger "selection" plots. Here the standard of prolificness is maintained by "mass-selection." At each harvest sufficient grain is obtained by hand-selection of the best ears of the most vigorous plants to sow a plot of similar size the following year. The balance of the plot is stripped and sown on the "seed plot" (½ acre in area). The produce of the "seed plot" is transferred to the "bulk plots" (10 acres), and the seed from this is distributed to the farmers. Comparison was made last season of the yields of twenty standard varieties from plots sown with seed subjected to this

method of selection with yields obtained from the same varieties unselected. This comparison shows a striking increase in acre-yields in favour of the selected seed; in some cases this increase is nearly 13 bushels, and is never less than 3½ bushels above the unselected seed.

These and other experiments justify Mr. Richardson, who is in charge of this work, in anticipating that the adoption of this system will make it possible to increase the prolificness of the standard varieties by at least 20 to 25 per cent. The production of new varieties by cross-breeding is being carried out at the three departmental stations referred to. The result of last year's tests at Rutherglen in small plots proved that a number of fourth generation cross-breds give yields as high as 45½ bushels to the acre, as against 32 bushels from the check-plots (Federation).

Two new varieties of particular promise have been obtained by crossing Federation with Indian F (a beardless, compact, early-maturing type obtained from Pusa). At Longerenong these wheats matured ten days to a fortnight earlier than Federation, and gave from 28 to 37 per cent. increased yields. A large number of crosses have been made between standard Australian varieties with Manitoba and with Russian hard red wheats, but so far without any notable success.

The object kept chiefly in view in the creation of these new varieties is that which Mr. Farrer set before himself, namely, the production of a wheat which shall be at the same time prolific and one of high milling excellence. In the pursuance of this object the experimental flour mill and electric baking oven are of considerable assistance.

SOUTH AUSTRALIA.

South Australia was the first of the States to undertake the systematic improvement of wheats, and the first Australian wheat-breeders belong to this State.

In 1881 the late Dr. Schomburgh, Director of the Botanic Gardens, Adelaide, supplied a few farmers in South Australia with samples of Du Toits, a variety of wheat grown in South Africa. One of these farmers, Mr. Ward (now resident at Port Pirie), observed a single rust-free plant in a crop that was otherwise eaten up with rust. From this plant was produced the wheat known as "Ward's Rust-proof," or "Ward's Prolific," a variety which has probably played a more important part than any other single variety in the improvement of wheat in Australia. For Ward's Prolific is not only a rust-resistant and highly prolific variety, thus enabling many farmers to carry on wheat-growing at a time when the prevalence of rust threatened to destroy the industry, but it is the parent of all the principal varieties that made wheat-growing profitable in South Australia, many of which have proved of even greater value than the parent wheat, and are strong favourites in the other States.

Even more successful as a wheat-breeder was Mr. Richard Marshall, who suffered severely from the depredation of rust and other cereal diseases. He set himself to study the disease and systematically experimented with a large number of varieties obtained from different parts of the world, and by cross-breeding and selection succeeded in producing a considerable number of varieties which completely replaced the wheats hitherto in cultivation.

Some of the best-known varieties we owe to this investigator are Marshall's No. 3, Marshall's Prolific, Silver King, Majestic, &c., and the great popularity of these wheats affords ample testimony to his success.

A new era may be said to have been introduced in South Australian wheat-growing by these creations of Mr. Marshall, and the older varieties of the Purple Straw, Tuscan and Lammas type almost disappeared to make place for wheats with harder grain and stiffer straw. Moreover, their cultivation enabled the farmer to compete with some measure of success against the ravages of rust. Their high-yielding power helped to make them popular favourites from the start.

Of the above-mentioned wheats, Marshall's No. 3, Silver King, and Majestic (all extensively grown all over Australia) are derived from Ward's Prolific, being either selected sports from that variety or crossbreds.

Yandilla King, another very favourite wheat, which we owe to Mr. Marshall, is a cross between Yandilla (Farrer) and Silver King (Marshall's), and hence a lineal descendant of Ward's Prolific. It will be seen what an immense debt the Australian wheat-growers are under to the two South Australian farmers, Messrs. Ward and Marshall.

Other notable varieties obtained by selection from Ward's wheat are Gluyas, Carmichael's Eclipse, and Budd's Early, and these have proved to be of even greater value than the original.

Probably the most extensively cultivated of all is the selection known as Steinwedel, named after a farmer in Balaklava, South Australia, who originated it. This wheat is extremely prolific and drought resistant, and has been for many years by far the most popular grain-wheat for the drier districts. It is still one of the few non-Farrer wheats recommended for cultivation by the New South Wales Department, though it is now giving place to stronger-flour varieties, and to wheats less liable to shell.

Other South Australian wheat-breeders who devoted their energy to the production of improved varieties suitable to South Australian conditions are Mr. Inglis, who is the creator of the rust-resistant variety that bears his name, and Mr. Leak, the originator of another "rust-proof wheat." Both these wheats are still widely grown.

These are the principal varieties we owe to South Australia, and before Mr. Farrer's wheats were created these wheats were grown practically all over Australia. It is no disparagement to them that they are being gradually replaced by varieties which have been more systematically and scientifically bred for special purposes. Many of Farrer's crosses are descendants of one or other of these wheats, and the names of Ward and Marshall are entitled to a very high place in the history of the development of wheat in Australia.

Departmental action.

Systematic attempts to improve wheats have been carried on by the South Australian Department for many years past. The most complete scheme is that introduced by Professor A. J. Perkins, Principal of Roseworthy Agricultural College since 1892, and now Director of Agriculture, South Australia. Professor Perkins bases his method on the assumption that selection, to be effective, must be continuous and uninterrupted. The broad principle underlying the method is that the best ears are selected from the "selection plots," and are used for the following season's selection plot. The process thus continues indefinitely and automatically, those ears possessing in the highest degree the qualities sought for being alone selected for further propagation in the selection plots. These plots have now been in existence since 1904, so that, with some of the original wheats, the ninth consecutive selection has been reached. Professor Perkins has very kindly supplied the subjoined description, which will make his method readily understood.

"We start with a limited number of good ears selected from well-grown plants in a standing crop, let us say King's White. The immediate progeny of these ears (with the exception of the best picked from them in the following season) I call King's White, first selection. The best ears picked from the best plants become King's White, second selection, and so on indefinitely, the very best ears always becoming one selection in advance of their immediate parents. At the present time we have reached our ninth selection with some of the earliest wheats handled.

"In any given year the picked ears are sown in what I term selection plots, *i.e.*, in rows 24 inches apart, each grain being dibbled in one link apart. Each ear is maintained separate under a number or letter, so that I always have several strains of the same variety, many of which are discarded in the course of time if they do not come up to expectations. In the same way all our wheats are strictly pedigreed in that I can trace them all back, strain by strain, to the individual original selections.

"In picking out the best ears attention is paid to the usual points. First, the plants must be thoroughly satisfactory, well grown, stooling normally, and not lodged in any way. Secondly, the largest and best formed ears are roughly picked in the field from the selection plots, and are subsequently handled in the laboratory. Thirdly, as much as possible we give preference to perfect ears, *i.e.*, those carrying no empty shells. Fourthly, ears are measured individually, and the number of spikelets counted; a record of this is kept throughout. Only those most satisfactory in this direction are retained. Fifthly, the ears are hand-threshed and the grain examined and counted; the best again are retained. Sixthly, and finally, the grain of individual ears is always hand-graded before sowing.

"After picking out the best heads for next year's selection plots, we run a stripper over the remaining plants, the grain from which goes into what I have called seed plots, extending over half an acre, 1 acre, or even at times

2 or 3 acres, according to the area occupied by individual varieties in the selection plots. In the year following these seed plots supply our farm seed, and in the year after that the seed is available for seed to outsiders.

"By these means our farm seed supply is constantly being renewed by more recent selections. The result has been most satisfactory; all our wheat is sold for seed purposes, and we are never in a position to meet all demands. The seed has gone all over Australia; and varieties which have been grown without change on the farm for between seventeen and eighteen years are still some of the best on the farm."

There is also a wheat research station at Turretfield. At this station a large and constantly increasing number of crossbred wheats are made and kept under observation in what are known as "crossbred plots." Last season sixty-eight new crosses were made. In addition to this are the "breeding plots," in which hand-selected seed of local and foreign wheats are grown in small plots, and made use of for crossing purposes.

Mention has been made above of the nature of the work carried out at Roseworthy Agricultural College. This institution deserves mention as being the first of its kind in Australia, being first opened in 1882. In addition to the selection plots described above by the Principal, the College encourages wheat cultivation by carrying out experiments in improved methods of cultivation and in the use of manures.

Other departmental farms which are particularly devoted to wheat are (besides Turretfield) Kybobolite, Veitch's Well, and Booborowie.

The Agricultural Bureau system, which originated in South Australia, and has been introduced into New South Wales, and already referred to, has also been an important factor in the improvement of wheat. The Bureau consists of a central advisory body, with branches in country districts, where meetings are held at regular intervals, papers read, ideas exchanged, and discussions held. Officers of the Department attend these meetings and discuss their special lines of work with the farmers, and the system provides an admirable opportunity for keeping farmers in touch with the Department. Experiment plots are also conducted by farmers under departmental supervision.

WESTERN AUSTRALIA.

In this State until recent years the most prominent wheat-breeder who sought to improve wheat by cross-fertilisation was Mr. G. F. Berthoud. He was also in correspondence with Mr. Farrer, and in the earlier days did a great deal of work in the selection of this investigator's wheats and in acclimatizing them both in New South Wales and in West Australia. Mr. Berthoud, after leaving New South Wales, started wheat experiment plots at Hamel in West Australia, about fourteen years ago, where he worked on the selection and cross-breeding of wheats, both his own and Mr. Farrer's. The outcome was the establishment of a State Experiment Farm at Hamel under Mr. Berthoud's direction.

The district was, however, found to be unsuitable for successful wheat-growing, the season being late and wet, and Mr. Berthoud abandoned his experiments.

He was successful in producing several new and valuable varieties of grain, which are still popular in Western Australia, the best known of which are:—

Alpha and *Crossbred No. 73.*—Both these wheats are of the same parentage, namely, crosses between Steinwedel and King's Jubilee, and are similar types of grain. They are early wheats, especially adapted to the drier districts.

Zealand is another very valuable variety which we owe to Mr. Berthoud. It was originally imported from France by him in 1888, and grown in the Corowa district of New South Wales. It is essentially a hay-wheat, and has held the position of first favourite for hay in New South Wales for many years, and is still the most reliable hay-wheat we possess for the Riverina and South-western and Western Slopes and Central Tableland. It is not a good variety for grain, the flour being of low colour.

Of the other more commonly grown varieties in Western Australia are:—

Lott's or *Gregson's.*—This belongs to the English Square Head type and originated with a Mr. Gregson, of York, West Australia, from a single selected ear. A neighbour, Mr. Lott, was also instrumental in distributing it, so that it is known under both names. It is one of the most prolific of late mid-season soft wheats, and in West Australia rivals Federation in this respect.

Penny's is another selection from Square Head wheat, and is also the produce of a single ear. It originated with Mr. Penny, of Green Hills, Western Australia, and is a similar grain to Lott's. It is also very popular in Western Australia.

Mr. Joseph Correll, of the Arthur River, Western Australia, who has made a close study of wheat for the past thirty-nine years, has recently succeeded in raising several new varieties, some of which are already deservedly popular and increasing in public estimation, as well as several others which Mr. Correll expects will prove even more satisfactory.

Le Huguenot is the best-known of these outside Western Australia. This variety originated from a single plant with two beardless heads in a crop of Medeah (a bearded wheat of the Macaroni or Durum type). This plant was harvested separately and sown in the following season, 1898, and has now been fixed for some years. The variety appears to be the result of accidental cross-fertilisation. It is particularly valuable as a hay-wheat, as it possesses all the qualities of the best of the Durum wheats, and has the advantage of being beardless. It is one of the varieties recommended for cultivation for this purpose in the coastal districts of New South Wales. It is also a good grain producer, but it is as an improved hay-wheat that Mr. Correll created it, and it now rivals Baroota, the principal wheat grown for hay in Western Australia.

Mr. Correll has also been successful in fixing a number of promising varieties by the same process of the selection of single plants, apparently produced by natural cross-fertilisation. Of these, Correll's No. 5 is among

the best early or mid-season varieties. He has two varieties with solid straws and beardless, of similar parentage to Le Huguenot, which he will shortly distribute, and which he considers will be even more generally useful than Le Huguenot, in that they tiller better, hold in the ground better when ripe, and can consequently be better stripped. They are more readily threshed, and produce better and more abundant grain. These varieties he calls La Rochelle and De Conde, and they appear to be the result of natural cross-fertilisation between Medeah and a wheat called Hawkes Club, a field of which was growing alongside.

Other varieties (Correll's No. 7 and No. 8) are also hay-wheats and bunt and smut proof, and will probably be found to be rust-resistant.

Of the grain wheats, the one which Mr. Correll considers most promising is No. 10, which will shortly be available for distribution. This has long square heads free from tip beards, with purple straw, comparatively short straw, and very shotty grain. Mr. Correll's wheats, as will be seen, are all the products of selection of two or three natural crosses with Medeah as one of the parents.

Among the more recent enthusiasts to take up the matter of wheat-breeding in Western Australia is Mr. W. Catton Grasby, of the Perth Technical College and the *West Australian* newspaper. Mr. Grasby was for some years in communication with Mr. Farrer and Mr. Richard Marshall, of South Australia.

He carried on wheat experiment plots in West Australia in co-operation with the late Mr. Charles Harper, and since Mr. Harper's death has continued this work alone.

Mr. Grasby has been successful both in selecting special wheats and in cross-breeding. The principal objects at present aimed at by him are the creation of early-maturing varieties possessing stiff straw and the production of hay-wheats. In this latter respect very promising results have been obtained by using Huguenot as a parent. Tall, well-stooled wheats result, and there is every likelihood of one or more of these wheats taking the place of Baroota, the present favourite. Crosses between Alpha (Berthoud's) and Federation (Farrer's), and also between Federation and Rerraf (two Farrer wheats), give considerable promise, being notably early-maturing varieties, and escaping mildew, which did a great deal of damage in Western Australia last season. Some of these crosses will be ready for distribution in a couple of years' time.

Departmental action.

Largely through the instrumentality of Mr. Grasby, the Education Department has introduced wheat-growing as a subject for Nature Study in schools. Mr. Grasby has placed at the disposal of the Department the produce of his own experiment plots, including a number of cross-bred varieties of his own creation.

It is anticipated that the work will prove of great commercial value to the State, although the plots are intended primarily to be educational.

During recent years a small wheat-testing mill has been installed, which will enable new crosses to be tested for their milling qualities, and so save the waste of time in cultivating varieties which later are found to be useless on account of their poor milling quality. An interesting investigation has been recently carried out by Mr. E. A. Mann, the Government Analyst (who is in charge of the testing mill), in conjunction wtih Mr. Grasby, on the effect of manuring on the milling quality of wheat. The results obtained would seem to indicate that the addition of potash, and, in a lesser degree, of lime, to the crop increases both the gluten content and also the water-absorbing power of the flour obtained.

Of the experiment farms under the control of the Department of Agriculture, those at Chapman, Narrogin, and Merridin are especially devoted to wheat culture.

The functions of these farms are defined as follows by Mr. G. L. Sutton, Agricultural Commissioner for the wheat belt, under whose control they are:—

1. To conduct reliable and systematic experiments and investigations, having special reference to the requirements of Western Australian conditions.
2. The production in commercial quantities of pure seed-wheat of the standard varieties, for sale to farmers.
3. The production, by cross-breeding, of new and improved varieties of wheat specially suitable for the various climatic and soil conditions of Western Australia.

Field trials and stud-wheat trials to determine the most suitable varieties are also in operation.

In connection with 3, the production of new cross-breds, Mr. Sutton remarks that "the greatest consideration will be given to the production of prolific varieties, but at the same time no effort will be spared to produce varieties that are also disease-resistant, drought-resistant, and of high milling quality. Before a new variety is made available for general cultivation, it will have to pass very severe tests."

When Mr. Sutton entered upon his duties as Commissioner in Western Australia, two years ago, he found that the most urgent work was the production of pure seed-wheat, of which there was practically none available. He is now able to report that he has for distribution this year from 10,000 to 12,000 bushels of clean, graded, pedigree seed.

QUEENSLAND.

The Agricultural College at Gatton and the State Farms at Roma, Hermitage and Gindie are all engaged in wheat culture, the farms at Roma and Hermitage being more particularly devoted to the production of wheat. At these farms variety tests, manurial trials, and seed-wheat plots are all in operation, and seed-wheat true to type is grown to supply farmers.

The late manager of the Roma State Farm, Mr. R. Soutter, now devotes himself exclusively to work in cross-fertilising. In all the wheat-growing districts of Queensland, farmers' experiment plots have been established, in which variety tests and manurial trials are carried on. There is also a small model wheat-testing mill in operation under the charge of the chemist, Mr. J. C. Brünnich, on which small parcels of wheat can be milled and the flour tested and baked.

It will thus be seen that Queensland, though not a wheat State, has not neglected to provide facilities for the improvement of this cereal. Of individual wheat-breeders who have produced wheats of lasting value I am unable to find any record. The names of Dr. Bancroft, Mr. F. M. Bailey (the Queensland Government Botanist), and Mr. Steiger are well known for their work on wheat diseases (particularly rust) in the late seventies and early eighties. Dr. Bancroft in particular imported and tested a great variety of wheats from other countries with the object of acclimatizing them to Queensland conditions, especially in regard to their resistance to disease.

From the above it will be apparent that a considerable amount of attention is being devoted to wheat improvement in Australia, and that the several State Departments are fully seized with the importance of the subject, and afford ample encouragement to its prosecution.

The subject of wheat improvement in Australia is so large that I am very conscious of not having been able to do anything like full justice to it. Numbers of improved varieties are brought forward from time to time as the result of selection, and names are often given to them in order to distinguish them from the original variety. These, however, do not usually enjoy a lasting vogue, and as it would be invidious to mention one or two without mentioning all, I have confined myself to speaking of those varieties that are well established favourites, or which, being the result of scientific selection or cross-breeding, give promise of playing an important part in the future.

In dealing with a subject in which four or five States are in friendly rivalry, it is not an easy matter to apportion fairly the work done by each, and to avoid giving undue prominence to any particular State or to any special line of work.

I am conscious that New South Wales bulks rather largely in the foregoing. If an apology is needed for this it must be found in the fact that I am personally very much better acquainted with what is being done in this State than in the others. Further, New South Wales really has done more than the other States in the matter of wheat improvement. Apart from Mr. Farrer's work, which everyone will admit overshadows that hitherto done

by any individual in Australia, and apart from the incentive given locally to wheat improvement by that work, the New South Wales Department has a larger and better equipped organisation, a greater number of experiment farms, plots, &c., than is the case with the other States. If I have done any injustice it has been unintentional and due to ignorance and not to prejudice.

I have received a great deal of valuable information from individual workers in all the States, both as regards their own work and that of others. Of those not specifically referred to in the text I would like to thank the officers of the New South Wales Department for much information both given verbally and taken from their writings, to Mr. M. Kahlbaum, Manager of the Adelaide Milling Company, one of our highest authorities in Australia on scientific wheat-milling, to Mr. H. W. Potts, Principal of the Hawkesbury Agricultural College, and to Mr. J. B. Trivett, Government Statistician for New South Wales, the last-named for tabulated data regarding yields and production.

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